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Chapter 5 - DISCUSSION AND CONSLUSIONS

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AN ASSESSMENT OF AVIAN AND OTHER SCAVENGING OF AN ANIMAL CARCASS AT KATERNIAGHAT WILDLIFE SANCTUARY, DISTRICT BAHRAICH, UTTAR PRADESH – INDIA, AND ITS FORENSIC IMPLICATIONS.

A DISSERTATION SUBMITTED AS PART OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE IN

FORENSIC ARCHAEOLOGY: CRIME SCENE AND INTERNATIONAL INVESTIGATIONS

By

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CHAPTER 5 – DISCUSSION AND CONCLUSIONS

5.0. Introduction

Access by faunal scavengers is one of the factor that can radically affect the rate and manner at which a carcass decomposes (Haglund, 1996; Vass, 2001). It is important to understand the alterations and / or modifications (morphological changes, disarticulation and scattering of remains and post-mortem artefacts) caused by such faunal scavengers to the scenes or the remains in any forensic investigations. The present study portrays the alterations and modifications caused by the involvement of: avian; mammalian; and reptilian; scavengers in the taphonomic process of the decomposing buffalo carcass. The results obtained are discussed and concluded in this chapter and are specific to this investigation.

Approach to the carcass by the actors

5.1.1. Discussion

The initial approach to the carcass was by the WBV and JC and it supports the inferences made by France *et al.* (1996) that the avian are often the first scavengers on the scene of shallow burials or

surface deposits. The focus of this study is that of the remit of the Forensic Archaeologist and therefore emphasis is placed on search, location and recovery and consequent interpretation of the scene. The present study indicated the method of locating a carcass by an avian species, i.e. vultures were observed flying in a direction and circling around in the sky at a specific location. On investigation it was learnt that there was the buffalo carcass on the ground to where the birds were seen circling. Similar observations were made by Killam (1990) and Davis (1993) where magpies and vultures were seen on different locations circling above the carcasses. This may be because, flight allows areas to be searched for carrions, much more rapidly and vultures have the ability to detect food from distances greatly in excess of 150 metres (Fischer, 1969). In addition, vultures also rely on observing the activity of the other birds and they are in constant visual contact with several other individuals of their species (Satheesan, 1998). Thereby a chain of behaviour is initiated which can lead to individuals of the same species approaching the carcass in large numbers (Houston, 1974). This was observed in the present research where fifteen WBV followed by fifteen JC were observed approaching the carcass on the first day. However, the EV was observed from the fourth day onwards, after the arrival of the crocodiles. This may be because the population of EV was not in large number and the information about the food source was not conveyed until the fourth day. In addition the EV feeds on soft tissues, tendons and cartilage (Satheesan, 1998) and this delay may be because the carcass was not sufficiently exposed till then.

The mammalian actors were the last to approach the carcass. This may be because the availability of the carcass was not known until the fifth day, the mammalian scavengers need to locate food at greater distances (Ruxton *et al*., 2004), and the population seen at this site was small. However, the crocodiles were the closest to the carcass but did not approach until after the WBV and JC. This may be because the presence of this carcass was not noticed until the arrival of the avian species. However, all the actors were observed returning repeatedly to the carcass during the study period, (see section 4.4, Table 4.5 and Appendix 11). This is similar to findings by France *et al*. (1996) indicating that hawks, vultures and other birds and animals will visit a carcass repeatedly throughout the scavenging process. This suggests that the actors preferred to return to an established food source rather than investigate other available resources.

5.1.2. Conclusion

Avian species were the first to approach the carcass. Flying is more advantageous for a scavenger than terrestrial movement to locate the food source. Population of species affects the number of approaches and thereby scavenging activity. This study also concluded that the actors returned to an established food source rather than investigate other available source.

5.2. Relationship between actors with respect to mutual or separate carrion feeding

5.2.1. Discussion

As there were six different species of actors involved in the scavenging process, it was interesting to understand their relationship. It was observed that there was no interaction between the various actors, (see Appendix 11). The independent species of actors took turns to scavenge the carcass, i.e. in presence of the crocodiles, the other actors were not seen approaching the carcass and vice versa. Dominance and fear could be a few possible reasons for this behaviour. This could be supported by the observations on site. It was seen that in the presence of the WBV, the other smaller avian species did not approach the carcass, which was similar to the observations by Morse *et al*. (1983) that the birds are generally able to assess relative dominance. It has been observed that

individuals of the same species feel a threat from another species (Ruxton *et al*., 2004). One of the reasons that the WBV did not approach the carcass in the presence of the reptilian and mammalian scavengers was probably because they are very large birds lacking agility and manoeuvrability (Houston, 2001), and therefore cannot escape from threats quickly. JC were not observed at all after the arrival of the EV. The possible reasons for this may be that the JC were sufficiently fed after successive returns to the carcass for four days, they found another food source, or the available carcass at this stage did not further interest them. Perhaps the avian and mammalian actors were alarmed by the presence of crocodiles, i.e. during the study period at the site a dog was observed being attacked by the crocodiles while drinking from the irrigation canal. This fear of crocodiles appeared to be stopping simultaneous feeding from the carcass leading to reduced number of approaches by vultures.

Conclusions

Actors involved in this study were con-specific with respect to carrion feeding, and did not show interaction with the other actors involved. Dominance and fear affected the number of approaches to the carcass. From the above discussion, it is concluded that due to the lack of the number of vultures present at the study site the expected result as seen in the literature, (see section 2.3), was not achieved.

5.3. Stages of decomposition and approaches by the actors

Discussion

Various scavengers may have a preference for food at different stages of decomposition (Haglund, 1996). The timings of approaches by the various actors in the present study, during the different stages of decomposition may be due to their general behaviour, availability of the carcass and accessibility of preferred anatomical elements. It was observed that the maximum number of approaches took place from morning until early afternoon, declining thereafter. Avian species have been observed consuming food during daylight in order to fly for longer periods later on, and for enhancing their metabolism (Satheesan *et al*., 1990). The mammalian species were also observed scavenging in the mornings. The maximum approaches by the crocodiles was in late afternoon, suggesting perhaps it prefers to feed during those hours, although there is nothing in the literature supporting this.

It was observed that the maximum number of approaches by the avian species occurred in the bloat stage, declining in the later stages. This may be because it was newly discovered and there was no threat by other types of actors which meant the availability and accessibility to huge amount of food source. Vultures are unusual as they can eat putrid carrion that would poison many other animals (Brooke *et al*., 1991). Odours attract the appropriate fauna to the carrion (Payne *et al*., 1968) but it is still unclear in the literature if vultures that are soaring at high altitudes are guided to their meals by sense of smell. There were strong odours on the second day of the study period and it coincided with the arrival of the crocodiles so perhaps the crocodiles are attracted by smell.

Removal of soft tissues of exposed or partially exposed human remains at various stages of decomposition, is brought about by the vertebrate scavengers, such as avian, mammalian or reptilian (Lyman, 1994; Haglund *et al*., 2001), colonization and succession of various flies and insects (Dadour *et al*., 2001). The number of approaches by the avian scavenger reduced

considerable during this stage compared to the bloat stage although, as discussed in section 5.2 above, this maybe reflecting the frequent approaches of other actors, especially the crocodiles. The onset of the active decay stage advanced the insect activity and witnessed all three types of actors feeding. The possible reasons for this could be that at this stage the tissue softens, flesh was exposed and internal organs and muscles were accessible. The natural process of decomposition and the progression of insect activity make access easier for the various actors to scavenge. The number of approaches by the WBV and JC was higher during insect succession and both were observed feeding on the insect larvae, which is similar to the findings described by Komar *et al.* (1998b). But scavenging may considerably alter anticipated rates of insect succession also. This occurs when scavengers consume insect larvae along with body parts (Willey *et al.*, 1989). The FD and CF were observed to be feeding on the limbs infested with maggots and hence the consumption of insect larvae may be assumed to be incidental to feeding on the limbs. Although crocodiles approached the carcass when the insect activity was present, the rate of consumption by the crocodiles was slower during this period. In the present study all the actors involved would have affected the insect succession.

However an interesting observation of crocodile behaviour was seen during the advanced decay stage. The rate at which the crocodiles scavenged was observed to be high during this stage leading to complete skeletonization by the next day. This coincides with the day when there was no insect activity evident. It may be suggested that insects have a negative influence on the crocodile scavenging behaviour but this seems unlikely. In a situation where the victim is stabbed to death and left near a place infected with crocodiles, there is a possibility that the crocodiles can reduce the victim's body to bones in a short period of time even before the maggot activity begins.

5.3.2 Conclusion

Avian and mammalian scavengers involved in this study approached the carcass from morning until early afternoon while the crocodiles approached later in the day. The number of approaches by the avian species was highest in the bloat stage reducing by more than half in the active decay stage. The above discussion also concluded that the maximum type of actors approached the carcass during this stage. Crocodiles were responsible for major scavenging in the advanced decay and dry remains stages in absence of insect activity, (see section 4.4.3, Table 4.7, Appendix 11 and 12).

5.4. Anatomical sequence and scatter pattern

5.4.1 Discussion

Accessibility and availability are defining parameters to this observational study, i.e. empirical evidence is not available to date regarding absolute preference of the actors for various anatomical elements or parts. In the present study, the WBV and JC were seen approaching the most convenient parts of the carcass for easy access to soft tissues, i.e. the eyes, nose and the anus, which is similar to the observations made by Pickering *et al.* (1997) and Komar *et al.* (1998b). WBV do not have the strength to tear the hide of a large animal such as a cow or buffalo, but can thrust their long necks in through the mouth of the carcass and into its anus to rip out the intestines (Attenborough, 1998), which was a phenomenon observed in the present research. Birds have demonstrated the ability to move anatomical fragments and skeletal elements, particularly ribs and fragmented cranial and facial bones (Komar *et al.*, 1998b). In the present study the WBV and EV did not however do this. This is because the approaches made by these birds were largely dominating

during the first three to four days when the carcass was still in the active decay stage and there were not many much of skeletal elements available for scattering. However, a JC was observed carrying the coccygeal vertebra (an accessible and available skeletal element) away from the primary deposition site on day three, to a considerable distance, (see Figure 4.13).

The FD and CF arrived on the fifth day of this study and were observed feeding on the limbs. This may be perhaps due to the inadequate availability of the carcass at that time, due to their late arrival, or as their scavenging preferences. Similar findings were made by Willey *et al*. (1989) in an experiment in Tennessee, as a component of the scavenging preferences of canids. This was: abdominal cavity; the internal organs; and the meaty portions of the limbs; neck and face. The most frequently observed articulating anatomical components from a human carcass which has been scavenged are: the head with the atlas and axis; the rib cage with some cervical and thoracic vertebrae, including the sternum; the scapulae and upper extremities; and the lumbar vertebrae, pelvis and lower extremities, particularly the tibia and fibula (Haynes 1982; Haglund *et al*., 1989). This suggests that the carcasses utilized by larger scavengers, are taken apart in predictable patterns, which make certain groups of bones available for transport together (Haglund *et al*., 1989) and leaves limited remains for late-comers to the scene.

No literature was found that attributed either direct or indirect evidence of disarticulation by crocodiles. There are published records of attacks by crocodiles (Scott 1994 and Vanwersh, 1998) but none on their scavenging behaviour. This observational study witnessed the nature and extent of scavenging and scattering by these reptiles. When the crocodiles attack, which may be fatal, it is seen that, they usually catch their prey, drag it in water and rotate until part of the body of the victim, such as the head or an appendage, is dismembered from the rest of the body (Iscan *et al*., 2000). In this case, it was observed that the crocodile removed the most accessible part, i.e. the intestines that had been pulled out previously by the vultures, and followed the same procedure of rotating with the part in the water. Several prey animals have been found wedged under submerged branches and stones, leading to reports that the crocodiles store their prey here until a later date (Alderton, 1991). Some reports also claim that it is necessary for the prey to decompose before the crocodiles are able to tear portions of flesh off, but this is unlikely to be true (*ibid*). The explanation for scavenging by crocodiles in this present study may be a consequence of their preference for carrion over fresh food. This needs further work to be carried out.

It was also observed that the crocodile showed preference for the part where the incision was made by the author as the soft tissue and the internal organs of the carcass were more easily accessible. The limbs of the carcass were not scavenged until the dogs tore the hide and exposed the flesh for the crocodiles to feed in their absence. It may be assumed that during predation crocodiles do not specifically consider the accessible areas in the victim, whereas while scavenging they do need an accessible point to start feeding. The maximum scattering was done by the crocodiles during the study period and this reflected the body and tail movement of the crocodile. They were not seen carrying or dragging any skeletal elements of the remains.

5.4.2 Conclusion

As expected, the avian scavengers fed on the most accessible orifices of the carcass. In addition, as they approached the carcass mostly during the bloat and active decay stages they were not responsible for scattering of the skeletal remains. The mammalian scavengers fed on the limbs and were responsible for scattering the skeletal remains in a predictable pattern, transporting certain

groups of bones together. The crocodiles approached the most accessible anatomical parts and skeletal elements of the carcass. They were responsible for scattering of the remains due to their body and tail movement.

5.5. Weather

Discussion

The sequence in which scavenging occurs depends upon factors dictated by the remains, the actors, climate and environment (Haglund *et al*., 1996), suggesting that when an individual dies in an exposed environment, their remains are subject to scavenging by carnivorous animals of that climate and environment. This study observed and recorded the actors that were common to that environment. The time taken for a corpse to decompose depends invariably on climatic conditions, such as the ambient temperature followed by moisture and rainfall (Rodriguez *et al*., 1983). It also affects medico-criminal evaluations (Skinner *et al*., 1983). Temperature has a direct influence on the decay processes; very low or very high temperatures slow down organic matter decay inhibiting bacterial proliferation and preserving corpse tissues longer (Mann *et al*., 1990). The temperature on the fifth day was highest compared to all the other days in both terms, i.e. average temperature as well as the maximum temperature during all the days recorded at 1200 hours which was similar to the findings by Shean *et al*. (1993). He also suggested that maximum temperature is more important than minimum temperature in accounting for the variation in decomposition rates. Maximum temperature on fifth day of this present study coincided with the day where maximum types of species were observed approaching the carcass. This was similar to observations by Vass (2001) indicating that warmer temperatures increase the number and type of scavengers as well as increases insect activity producing faster degradation of the corpse (Vass, 2001).

Increased humidity coincided with insect activity on day two of the present study and this produced an amplified food source for the avian scavengers, resulting in maximum number of approaches by the avian scavengers on the carcass. These observations support the suggestion made by Mann *et al*. (1990) that increased humidity may be correlated with increased fly and maggot activity. However, the decline in humidity and end of insect activity did not stop the actors from approaching the carcass. It was seen that crocodiles acted more efficiently during this period. It may be perhaps that humidity did not affect the approaches by the actors involved, but did affect insect activity.

In addition to temperature and humidity, rainfall, to some extent, also affects the rate of decomposition of a corpse (Mann *et al*., 1990). In ecology, rainfall influences the vegetation in turn influences the faunal species that can exist in that location (Paulson, 1996), although not immediately. As suggested by Mann *et al*. (1990) that rainfall may reduce the insect activity. The data collected from the source for rainfall seems to vary dramatically with the actual observations. The analysis of the data shows no evident comparison between the approach by the actors and the maximum and minimal rainfall. However, on reflection this was not the case as there were light showers throughout the day at regular intervals except on the third and fourth day. This correlated with, and may be a reason for the decline in number of approaches by the vultures on those days. As vultures are very large birds, they need to be light in flight (pers comm. Satheesan, 2005) and the rains would make their wings wet and heavy, thereby inhibiting their scavenging activity. In addition, according to the divisional forest officer at KWLS, the vulture populations reduce in the rainy season i.e. July - September, and then increase, starting with the breeding season in October.

Hence, in the present study it is possible that the absence of a large number of vultures facilitated other scavengers, such as: crows; dogs; foxes; and crocodiles, playing a larger role in disarticulating, devouring and reducing the buffalo carcass to a skeleton than had been anticipated.

5.5.2. Conclusions

The above discussion concluded that the maximum temperature directly related to the maximum number of type of scavengers observed on the same day. It also noted that increased humidity was evident on the days of maximum insect activity, and resulted in higher number of approaches by the avian scavengers. However, this may be a coincidence rather that cause and effect. Field observations indicated that showers had a negative influence on the number of approaches by the vultures than anticipated.

5.6. Overall Conclusion

This observational study has successfully confirmed the involvement of various actors in the taphonomic process of a decomposing buffalo carcass. It has also confirmed that within a duration of seven days a large animal carcass can be reduced to bones, and that the scavengers including; avian, mammalian, and reptilian may be alone and / or collectively responsible for this effect.

This study concluded that avian scavengers precede terrestrial scavengers in locating the food source. Actors involved in this study were con-specific with respect to carrion feeding, and did not show interaction with the other actors involved. It also concluded the expected observation of the actors repeatedly returning to the established food source rather than investigating other available source throughout the study period.

This study confirmed that dominance and fear with respect to inter-specific scavenging, affected the number and timing of approaches to the carcass. Population of species, i.e. the number of species at site, also affected the number of approaches and thereby scavenging activity. In addition, due to the lack of the number of vultures present at the study site the expected result was not achieved. The avian scavengers were more dominant during the bloat stage declining thereafter. It also concludes that the avian scavengers fed on the most accessible orifices of the carcass during the bloat and active decay stages and they were not responsible for scattering of the skeletal remains.

This study concluded that all three types of actors participated in the active decay stage. The mammalian scavengers fed on the limbs and were responsible for scattering of the skeletal remains in a predictable pattern, making certain groups of bones to be transported together.

The crocodiles importantly showed for the first time that crocodiles are scavengers as well as predators. This observation has not been made in the published literature. Scavenging by crocodiles in this present study, may be a consequence of their feeding preference for carrion over fresh food but further work needs to be carried out for similar observations. They were responsible for major scavenging in the advanced decay and dry remains stages in absence of insect activity. The crocodiles approached the most accessible anatomical parts and skeletal elements of the carcass. They were indirectly responsible for scattering of the remains due to their body and tail movement. This study also confirmed that the temperature, humidity and rainfall may have had an influence on the actors and their involvement in the taphonomic process of the decomposing buffalo carcass, though it is hard to determine if this was real or simply coincidental. This research clearly highlighted the opportunist scavenging behaviour of crocodiles and its effect on the carcass.

The observation suggested that the rate of consumption of the crocodiles increased in the absence of any insect activity.

That crocodiles are scavengers is a very important finding for crime scene investigators and forensic archaeologists involved in search and location exercises. This may give clue of the type of scavenger involved in any criminal investigation where the recovery of skeletal remains is from or near a water body infested with crocodiles.

This study has underlined the need for having an understanding and knowledge of scavenging behaviour of these actors, i.e. recognizing the modifications by these actors to scenes and remains for accurate crime scene interpretation. The scatter pattern due to scavenging in this study will assist the forensic archaeologist in using appropriate techniques to search, locate and recover the human remains from a similar scenario. This study has also showed that there is still much that is not recognized or well understood. This research has stimulated interest and generated several research ideas.

As an exploratory exercise the dissertation has fulfilled its aims and objectives and has thus provided the impetus for further study.

5.7. Limitations

There were a number of limitations to this observational study some of which had not been anticipated from the literature review. These will however serve to inform future taphonomic studies in this or similar regions.

1. The potential risk to personal safety from wild animals and criminal lead to health and safety constraints that limited the proposed 24 hour recording of the scavenging activities. Another reason for not having a 24 hour recording was due to the unavailability of electricity. Both sites were in the buffer zone of the forest which was infested with wild animals and had a recent report of a fatal tiger attack killing a young male working in the nearby field. The area was also frequented by terrorist groups from a neighbouring country, i.e. Nepal. Logistically, the site was inconvenient and unsafe to travel to during early hours and late evenings as the general infrastructure was poor.
2. A wire-mesh enclosure was not used to deter faunal scavengers from accessing the carcass observed in this study for several reasons. These are as follows: First, because of the expense involved in creating an enclosure of the dimensions required. The minimum size required had to be 100m X 100m X 3m, to allow the huge sized avian scavengers safe landing and take off from the site of the carcass. Secondly, site B was surrounded on three sides by an irrigation canal, which was infested with crocodiles hence fencing could not be put in place, which meant that interference from faunal scavengers could not be avoided.
3. For ethical and religious reasons, a goat and buffalo carcass was used as an analogue to human cadavers. In this respect, the size of the buffalo carcass was also a limitation to the study in respect of analysis of scatter patterns. The buffalo is a comparatively massive animal compared to a human and also when compared to the scavenging actors involved at the site. It is likely that they could not to cope with the weight of the body parts, even if the carcass had been extensively disarticulated.
4. The presence of the buffalo carcass detracted the scavenging focus away from the primary carcass (the goat) and site (A). This meant that the site initially set up for the study became

redundant and that focus had to shift very quickly to the new site (B) involving some changes of approach and research emphasis. Such can be the nature of observational studies in remote areas with a diverse ecological system.

5. It was stated by the local vulture expert that the vulture species at the site have insufficiently sharp and powerful beaks to tear the thick hide of the buffalo carcass (unlike human skin), consequently it was decided to slit open a small section near the belly area of the animal carcass, to facilitate the activity of the actors. This of course, detracts from what would happen if no such access points were created.
6. The scatter pattern in this study was measured as offsets from NW – NE baseline, (see Figure 4.12 and Figure 4.13). It would have been more accurate to have used triangulations for accurate measurements but the tapes were not adequate.
7. The presence of crocodiles prevented the vultures that were in the nearby trees from perching on the animal carcass; as a result they fed on the carcass either early in the morning or later in the evening in the absence of crocodiles, restricting any evidentiary recording.

Even though ideally all of the above would have been countered, this study has produced some useful results despite the above stated limitations.

5.8. Recommendations for further work

The importance of proper infrastructure, research and planning is crucial when undertaking a research of this scale. Seasonal habitation must be investigated before conducting this kind of research to predict the available faunal population. In addition all primary data for the climate should be obtained from the recording data source of less than 10 km range to get the microclimate of the study area. In any further work of this kind, it would be ideal to focus on one species to get high yield and so using either platforms or enclosures for the carcass would be advantageous. The problem with using enclosures in avian scavenging studies is that many species of birds will not engage unless the open space suits their specific requirement for flight etc.

Measuring the scatter pattern of remains using triangulations will enable the Forensic Archaeologist to establish the spatial relationship in a criminal investigation thereby benefiting the overall reconstruction of the events. Twenty-four hour video recording especially with the night time recording facility will be beneficial to account for the nocturnal activities of the faunal scavengers which could be missed otherwise. A multi-disciplinary approach must be encompassed in research trials of this nature in the future. For example, employment of the expertise of entomologists and ornithologists, in providing their biological background and knowledge to aid the research deign and analysis. Co-ordination of the examination of skeletal elements with an osteologist would be beneficial in understanding any post-mortem artifacts.

In future, when considering the activity of the actors and assessment of which species may be involved, one needs to do a laboratory analysis of the animal and bird excrement and bird feathers that is found in the vicinity of the carcass or on the carcass itself. In addition, further work is recommended, including analysis and comparative study of the lesions, reflecting various teeth marks and possible impact of beaks on some of the skeletal elements that were recovered from the site.

Further work needs to be done to confirm the exact behaviour of crocodiles as scavengers and the rate of consumption at different stages of decomposition of the carcass. This will particularly assist

forensic investigations involving soft tissue trauma such as gunshot or stab wounds on the deceased. This needs further investigations to confirm the scatter pattern as it would enable the forensic archaeologist in their interpretation of the site during the recovery process in a criminal investigation. In order to understand trauma to bones by the teeth, further research is required to study the jaw shape and the dentition of the crocodiles this will inform the likely changes to bone after crocodile scavenging and scattering. Further work needs to be carried out to confirm the feeding preference of crocodiles for carrion over fresh food. Replication studies of this research are recommended to confirm the findings with respect to crocodile scavenging.

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